The Philippine Agriculturist and Forester

35 centavos a copy
₱3.00 a year

Foreign subscription
$2.00 a year

Entered at the Post-Office at Los Baños, Laguna, as second-class mail matter

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Vol. VI APRIL, 1918 No. 8

EDITORIAL

New and practically unknown, as scientific agriculture is in the Philippines, its future in this country will be determined largely by the manner in which it is presented to the general public by those who are in a position to give out the necessary information. For some time past, the different government branches concerned have been conducting an active campaign for the dissemination of agricultural knowledge among the people, both by publicity through the current periodicals and by actual demonstration work among the farmers. Public interest is now beginning to be aroused on matters pertaining to agricultural science, and present indications tend to prove that the agricultural class, in general, is composed of a group of people who are willing to be shown, and ultimately willing to adopt what appeals to them as a more reasonably correct procedure than what was formerly the local practice.

In attempting to introduce anything new, it is often difficult to win the popular mind in favor of the innovation; it is always easy to arouse their prejudices against it. Now that the Filipino farmers are becoming favorably impressed with the unlimited possibilities of scientific agriculture in this country, any step we may take in the wrong direction may absolutely upset the results of our hard labors of many years; and once upset, it will probably take a great many more years to reconstruct that which was once established. Nothing can harm our cause more than to prejudice the people against us—the supposed promoters of this science—by giving them any cause for believing that we are trying to subject them to delusion. The wrong kind of publicity, in particular, when detected, as it will ultimately and inevitably be, will at once and probably forever destroy the farmers' confidence in whatever we put in print subsequently; and they will thereafter be continually suspicious in our further dealings with them. To cite one specific instance:

A story once became widely circulated in the newspapers, obviously from some official sources, reporting the discovery of an effective remedy against the rice bug, or *atañgia* (*Leptocorisa acuta* Thumb). One simply had to secure a piece of

decaying meat, dust it with an arsenical compound, hang the bait on a pole in the rice field, and the bugs would eat the drugged meat and become poisoned. This sounds like a very simple process. (As if the rice bugs were provided with cutting mandibles to bite the meat with!) Subsequent experiments, probably by the same officials who advocated the treatment, at last showed that the rice bugs would not bite the meat, and, therefore, could not be poisoned by the arsenic, so that another statement had to be handed out to the press to the effect that arsenic was to be eliminated from the formula. As the case now stands we have: decaying meat, minus the arsenic; string to hang the meat with; and pole. The idea (revised) was to have the bugs go to the decaying meat, where they can then be burnt morning and afternoon. But further trials may show that the bugs are not attracted by the meat. The poor farmers will then have the pleasure of reading another change in the instructions—eliminate the decaying meat from the formula. This will leave only the pole and the string with which to catch the rice bugs; (and suppose the insects do not find enough attraction in the pole and the string?)

If we are to maintain our prestige as government officials whose duty it is to further the advancement of scientific agriculture in the Philippines, we must be very cautious in whatever we say or publish for the information of the masses. Methods that have not been thoroughly and successfully worked out and the practicability of which have not been definitely and finally proven, should never be introduced, or even mentioned, as the outcome is most likely to prove detrimental to our work. "Prove all things; hold fast to that which is good."

Shade for Coffee in Laguna

By Teofilo Guevarra Caliñgasan

Thesis presented for graduation from the College of Agriculture, No. 90

Although coffee is grown more extensively in the subtropics than in the hotter and warmer tropics, yet it can be made to produce at least as well in the latter regions as in the former by giving the plants adequate shading. Excessive evaporation, which invariably occurs in a warm climate, is unfavorable to coffee; this untoward condition can be prevented artificially by shading or protecting the plants from the excessive heat of the sun. In a country like the Philippines, where, except in certain mountainous provinces, the climate is warm through the greater part of the year, coffee requires more shading than any other Philippine crop. The heavy winds which prevail in the Islands during certain months make protection a necessity; to this end the shade trees serve a secondary purpose as windbreaks. In addition to these uses they prevent soil erosion, and if leguminous, improve the fertility of the soil.

Location, temperature, altitude and the strain of coffee determine whether shade is needed or not. In some countries, as in South Brazil, the use of shade trees was found unsatisfactory and wholly unnecessary. On the other hand, in some other countries, shade for coffee has been found very satisfactory and profitable.

In Central America, Venezuela and Colombia, the most commonly used shades for coffee are the leguminous trees. Brazil and the East Indies have tried different shade trees, such as figs and other non-leguminous trees, but the results were not at all promising. In some regions, especially in Java, green manuring with leguminous vines—vetches, clovers, fodder crops, and others—has been practised extensively and found satisfactory.

The plans to be followed in establishing a coffee plantation are determined by the presence or absence of shade trees. The selection of a suitable place for the plantation, the cutting down and thinning out of the forest, selection of trees for shade, spacing of trees, and cultivation and use of soiling crops are all part of the shade problem. These are all matters to be determined by the coffee planter from his observation of local condition. There are soils and climates where shade is absolutely unnecessary. There are soils where leguminous shrubs and herbs produce better effect and are more advantageous than shade trees, but in broken places, mountainous regions and in arid regions, as in some parts of Arabia and Mexico, leguminous shade trees are of great value. The need or value of shade trees, and the different kinds of trees best adapted to this purpose, should be given early attention in the Philippines.

ORIGIN OF VARIETIES (1)

Different strains of coffee need different amounts and kinds of shading, because of the fact that they originated in regions wherein the conditions of soil, climate and temperature are different. The Arabian coffee (*Coffea arabica*) is found in the forests of Eastern Africa. Watt states that it is a native of certain hilly regions of Abyssinia, of Soudan and of Mozambique, and Guinea—all of which are tropical countries. This species of coffee is found in these localities in association with shade trees. There are, however, some who doubt Watt's views and advance the idea that

its original home is Arabia, and that from this country it was carried to Abyssinia.

The Liberian coffee (*Coffea liberica*) has a different origin. It is a native of West Tropical Africa, especially of the countries of Liberia, Angola, Golungo and Alto. It is cultivated along banks of rivers and margins of plots in countries which are located very near the equator. The climate is much warmer and moister than in Arabia, which leads us to conclude that the Arabian coffee could hardly be grown and made productive in places where the Liberian thrives.

Robusta coffee (*Coffea robusta*) is a native of the Congo Valley. This type is very similar to Liberian in the manner of growth and reaction to environmental conditions. Like *liberica*, it requires a moist climate with little shade, a condition commonly found along banks of rivers and smaller streams.

It is understood that Arabian coffee originated from a forest region and the more or less delicate leaves make the plant less enduring to intense heat. The leaves of *arabica* consist of only one set of parenchymatous cells, covered above and below by thin cuticle. Plants of this kind are very easily injured by heat. The other two types (*liberica* and *robusta*) have the leaves with two sets of parenchymatous cells covered with thick cuticle. This leads to the conclusion that in order that the chlorophyll bodies may manufacture food properly, more light is needed.

SHADING IN SOME COFFEE REGIONS (*)

South Brazil is the most noted coffee region, not only locally in South America, but in the world. This country lies near the southern limit of the American tropics, and the rainfall is quite evenly distributed throughout the year, so that a constantly moist atmosphere about the plant, both in the soil and in the air is maintained. Hard winds never occur, and the climate, soil, and moisture supply is as perfect as we can get them in the tropics. Coffee is grown there entirely without shade and is most productive.

In the West Indies, Central America, Venezuela and Java, coffee is raised in a different manner. These countries are located in the tropics but they have conditions of soil and air moisture different from that of Brazil. Due to the prevalence of winds and dry weather, the use of shade is necessary in order to secure high production. In high altitudes in these countries shade trees consist mostly of leguminous trees serving for protection from intense heat, from wind, and from soil erosion, and the leaves and roots act as soil fertilizers. In the West Indies, particularly in Porto Rico, most of the coffee plantations are shaded. Cook (2) states that the mountain slopes are sometimes very steep, the grades running to 45°. Such being the case, erosion is rapid. This has been partly prevented by the use of shade trees the roots of which spread widely and hold the soil in place. However, coffee of some sort can be grown anywhere in the tropics and made productive on a rich, light and deep soil where the temperature is not too low and where it rains at frequent intervals during the year. The altitude of a place in its relation to the productiveness of the coffee plant must receive careful consideration.

In Arabia, coffee is grown under conditions that are entirely different

(*) See Cook, Shade in Coffee Culture.

from those of other countries. There, the climate is arid. The plants are irrigated on terraced hillsides at an elevation of 3000 feet above the sea level. Below this elevation, shade trees are used so as to have a moist atmosphere. In the southern part of Arabia, coffee is planted in lines and thickly shaded.

EFFECT OF WIND ON PRODUCTION

The injury caused by strong winds is even more serious than that caused by dry weather. A double loss to the farmer occurs when the plant is flowering and the hard wind occurs. The young flower is very sensitive to rapid change of climatic conditions and even those flowers left on the plant after a strong wind may fall off sooner or later. The developing young fruits are also injured by high winds.

Cook (3) states that in some localities, as in Ceylon, where open culture is practised, it is the custom to tie each tree to a stake to prevent the plant from being wind-wrung, or being whipped about until the bark is bruised or worn away, which would result fatal to the plant. This danger can be avoided by the planting of wind-breaks or leaving narrow strips of the natural forest uncut. In reality these do not protect the entire planting, but the danger is not so serious under such conditions.

In the Malayan regions, particularly in Java, the methods of sheltering from wind receives an increasing attention. It was found that better coffee could be grown near large trees, especially if these were legumes.

In certain parts of Porto Rico most of the coffee plantations are on the lower slopes of hills and on the sides of narrow ravines. Because these regions are often visited by hard winds, and dry weather occurs very often, the plantations are confined to such protected places. Wind is a factor in hastening evaporation from the soil, as well as transpiration from the leaves. When transpiration from the leaves can not be counterbalanced by the absorption by the roots, naturally the whole plant wilts, and finally the leaves fall.

EFFECT OF SHADE ON PRODUCTION

The primary consideration in connection with shade is its effect on the crops produced. The experience of many seems to indicate that it decreases the yield. The rays of the sun cannot penetrate through deep shade and the coffee plant receives insufficient light to manufacture food and its functional activities are hindered. Cook (4) states that in Porto Rico reduction to ⅓ of a normal crop is caused by overcrowding, overshading and other forms of negligence. In Central and South America large crops are produced under partial shade of leguminous trees. Of course it is obvious that in localities where the conditions are wholly favorable, at an elevation furnishing a mild and suitable climate, shade is entirely unnecessary, as is the case in some parts of Central America where the soil is of volcanic origin and conditions very favorable.

In the Philippines, in the Bukidnon region of Mindanao, the same conditions are met with; the coffee plants grow there to unusual size without shade, and have an average production of 3 pounds per tree and upward; individual trees sometimes yield 12, 20 or even as high as 40 pounds of coffee.

It is also true that spacing of coffee has relation to production. The closer the plants, the smaller the production within certain limits. If closely planted,

the roots come in contact with each other and the chances of absorbing food material from the soil are diminished. Close planting results also in ill-formed trees and scarcity of bearing wood.

In Java the largest trees are found on terraced mountain sides. They are planted 25 feet apart and at this distance they attain the height of 30 to 40 feet. The average produce may be only ½ pound per tree, or individual trees may yield from 6 to 7 pounds of prepared coffee. This is also the case in the Philippines. In the observations in this experiment on the effect of shade on growth it appeared that exposed trees produced more berries than shaded trees. This occurred both at low and at high elevations—on the college farm and on Mount Maquiling.

EFFECT OF SHADE ON QUALITY

Both elevation and shade affect the quality of coffee. Dr. Rusby (5) states that coffee, as well as coca, grown at high altitudes, where the humidity is less and more irregular, is better in quality, probably not so much because of the caffein- or cocaine-content as for the presence of other substances, known as sweet alkaloids, which give aromatic flavor to the berries.

However, the fine aroma of coffee is partly dependent on the quantity of caffein. The presence of this substance in the coffee seeds was found to be largely influenced by environmental conditions. It might then be expected that coffee grown under shade would have less caffein than the sun-grown coffee. Up to the present time this fact has not been carefully checked by chemical analysis; but the instance of cinchona furnishes a parallel case. Dr. Lotsy (6) made a similar investigation on cinchona trees grown in Java. He found that the amount of alkaloid is very definitely influenced by sunlight. Cinchona is like Arabian coffee in that it does not flourish at low altitudes, and receives practically the same treatment.

EFFECT OF SHADE ON RUST

Too much shade has another disadvantage. It produces such a degree of humidity as to favor the growth of pathogenic fungi. The destruction of Arabian coffee in Lipa about thirty-five years ago was due to overcrowding and overshading with madre-de-cacao trees,(*) accompanied by widespread rust infection. This tree furnishes very good shade for coffee if properly used, but too much of it is detrimental. The parasitic fungus (*Hemileia vastatrix* Berkeley et Broome) is exceedingly active on deeply shaded trees. Such dangerous diseases can be avoided partly by reducing the shade so as to permit free entrance of sunlight and free circulation of air. Cook (7) states that spores which germinate only in water are killed by exposure to sunshine. The primary cause of injury due to *mancha de hierro* and other fungi of coffee in Venezuela and Colombia is heavy shade.

From the foregoing observations, we may conclude that too much shade may be worse than none and it follows that the shade should be only of such a degree as to properly protect the tree and to secure conditions most favorable to its growth and productiveness.

WORK AT THE COLLEGE

The present work involves a comparison of growth of coffee of different varieties at low, medium and higher altitudes in shade and in the sun.

(*) *Gliricidia sepium* (Jacq.) Staud.

On the college farm five varieties under two distinct types—*arabica* and *robusta*—have been under observation. *Arabica* consists of Malaybalay, Caracolillo, Ceballos, and Jamaica; and *robusta* consists of only one—Bukobensis. They were planted in July, 1914, and by the time the observations began they were about 2 years old. From each variety the best plants found under shade and in the sun were chosen. The selected trees were each labeled with the name of the variety and the condition where found, that is, whether in shade or out in the open.

The following table (9) is a list of varieties used in this study and their origin:

TABLE I

Varieties	*Origin of seed*
(730) Arabica	Royal Botanic Garden—Calcutta.
(2776) Ceballos	Cuba.
(1606) Jamaica.	Jamaica.
(44B.) Caracolillo	Nueva Viscaya.
(642) Malaybalay	Bukidnon, Mindanao.
(2037) Canephora	Buitenzorg, Java.
(888) Bukobensis	Royal Biological Exp. Sta. Institute, Hafen Tanga, Deutsch Ost-Africa.
(1554) Dybowskii	Buitenzorg, Java.
(5493) Canephora	Bureau of Science.
(5492) Robusta	" " "
(5485) Quillou	" " "
(5488) Congensis	" " "
(5494) Madagascariensis	" " "
(5484) Uganda	" " "
(5597) Arabica	Native Arabica from Maajas, Los Baños (through Luistro.)

The following table shows the number of trees under shade and out:

Variety	*Shade*	*In Sun*	*Total*
Malaybalay	17	6	23
Caracolillo	23	7	30
Ceballos	9	10	19
Jamaica	15	15	30
Bukobensis	16	13	29
TOTAL	80	51	131

In order to have the best basis for comparison under the two conditions the number of plants under shade should be equal to the number of plants in the sun. In the present case, this was not possible, due to the insufficient number of trees for observation. Weekly measurements were made from May 20th, 1916, to February 24th, 1917, during which time considerable variation occurred in the climatic conditions which affect the growth. Six measurements were taken from each plant—1st, the growth of the main stem, determined by marking a fixed point in the region where the growth had ceased; 2nd, length of five primary branches by the same method used in measuring the main stem.

The diameter of the base of the plant was taken once a month at a distance of about four centimeters above the ground. Two diameters were taken because of the irregularity in shape of the base and the average of the two was considered the diameter of the stem.

The shade trees used in this experiment were too low and the branches were in contact with the coffee plants. This produced conditions very unfavorable to the growth of coffee, as the air could not circulate freely. And during the dry season the air was too hot while during the wet season it was too cool. Another condition unfavorable to the coffee plants was that the other side of the plantation is exposed level land planted to *Citrus* and sugar cane and other temporary crops which furnished windbreaks, so that when the wind blows from the southeast it caused great harm to the plants by drying off the soil very quickly. This irregularity of climatic conditions favors the successful growth of rust.

The other apparent results of irregularity of soil and climatic conditions are the asymmetric formation of the base of the stem and the unsymmetrical distribution of branches on the stem. Some plants will have vigorous branches on one side loaded with plenty of leaves but with only a few and small branches on the opposite side. Other plants will have their branches fairly uniform and equally distributed. Another characteristic of plant growth under heavy shade is that the plants become leggy, the leaves becoming larger than usual and thinner and fewer in number, with weak stems. In Bukobensis this characteristic is very apparent and in some types of *arabica* it can be recognized.

Though *arabica* and the Bukobensis types be subjected to the same condition of climate and temperature, they do not respond similarly to those conditions, and even the different varieties of *arabica* react differently.

The following table is the summary of growth records of different strains of coffee grown at the lowest elevation:

TABLE II

SUMMARY OF GROWTH RECORDS

MAY 20, 1916, TO FEBRUARY 24, 1917

LOWLAND PLANTATION

ELEVATION—50 METERS

(Measurements in millimeters)

Variety	*Average increase in diameter per plant*		*Average increase in stem per plant*		*Average increase in branch growth per plant*		*Date of most active growth*		*Date of stoppage of branch growth*	
	Shade	*No shade*	*Shade*	*No shade*	*Shade*	*No shade*	*Shade*	*No shade*	*Shade*	*No shade*
Ceballos	3.44	3.58	80.44	123.6	89.65	76.83	June	June	Middle of July	Beginning of September
Jamaica	3.64	1.56	88.6	57.13	89.39	48.26	May and June	May	Middle of July	Beginning of June
Caracolillo	5.02	5.26	128.38	125.22	194.69	123.24	June and July	June and July	Beginning of October	Middle of September
Malaybalay	5.39	5.1	119.64	61.66	169.6	136.7	May, June and July	May and June	Beginning of October	Beginning of October
Bukobensis	4.23	5.66	274.6	200.5	96.4	121.47	May	May	Beginning of June	Beginning of June

By examining this table it will be seen that different varieties react differently to the same soil conditions and temperatures. It was observed during the experiment both in shade and in the open that the most active growth is on branches near the growing region of the main stem. As the lower branches are observed, the growth is found to be less and less. This is true of all varieties under any conditions.

Jamaica.—The poorest variety of Arabian coffee grown in the lowlands is Jamaica. It cannot endure intense heat and, in the open, it makes the smallest growth of any variety. It shows that shade is indispensable to its growth in the hot lowlands. The main stem and even the branches of the shaded trees grow nearly twice as much as the unshaded plants. The shaded trees have a longer period of most active growth and the branches cease to grow later than trees in full sunshine. It was observed that the most active growth of shaded trees lasted till June while those in the open stopped soon after May 20, 1916, the date of beginning of this work. In the case of Jamaica the growth of shaded plants lasted till the middle of September. In July and August the growth began to lessen. In the sun the growth lasted for a very short time only, that is, till the end of June.

Ceballos.—Another variety that showed poor growth is Ceballos. This fact indicates that this variety is not adapted to the altitude of the college farm. Due to the fact that the plants under shade were too heavily shaded, the growth was less than in those in the open. The branches of shaded plants, however, grew a little better than in unshaded plants. The most active growth of the plants under both conditions was nearly the same in the same length of time. In the case of shaded plants, the growth lasted till the beginning of September. The growth was the least in the months of July and August. In the sun the growth lasted until about the middle of September and the increase in growth in July and August was very small, as compared with the increase in growth in the months of May and June. But the branches of the shaded trees ceased to grow at about the middle of July because of the inadequate food supply in the soil. The branches of the unshaded trees continued to grow until the beginning of September.

Malaybalay.—Experiments showed that, like Jamaica, this variety required shade for its growth when cultured at the elevation of the college farm. Table II shows that the growth under shade is nearly twice as much as in the open. The growth of the branches under shade was also considerably faster than those in the sun. Of all the varieties under experiment, Malaybalay has the longest period of active growth under shade. From May, when the experiment began, to the end of July it showed active growth under shade, while in the sun the period of active growth lasted from May to June only. The cessation of growth of the branches both in shade and in the open took place at the same time. This was partly due to the severe hot days during September and the succeeding weeks which affected the trees under both conditions.

The growth of the shaded plants, as well as the unshaded, lasted till the end of September. In the shade and the open the growth began to lessen in the months of July and August. The death of most of the branches occurred in October. At the beginning of this work this variety showed a very good growth, looked very healthy, was full of branches covered with plenty of leaves and producing more than any other variety grown on the college farm. Though there was little rainfall during the month of October, the moisture produced was unfortunately sufficient to favor the growth of *Hemileia*. The

spread of this disease was then so rapid that towards the end of October very few leaves remained on the plants.

Caracolillo.—Another variety of *arabica* which can be recommended for this elevation is Caracolillo. According to the figures in Table II, it has the most rapid growth of all the varieties. It received the same amount and quality of shading as the Malaybalay and Jamaica and was grown on a similar soil. It was found to respond more readily to local conditions than any other variety.

From the results of the growth measurements of the main stem, it appears that shade is not very necessary to Caracolillo. However, light shading should be given to the plant so that it may not suffer too much from intense heat. With this variety also, the unshaded plants grew less than the shaded plants. The length of time of most active growth was practically the same but the branches of unshaded plants ceased to grow as early as in the open. In the sun the growth of the plant lasted until about the beginning of September. Some of the branches stopped growing at the end of July. In the shade, the growth had a gradual decrease, but lasted till the end of September. Towards the end of July and the beginning of August there was a slight increase in growth. Only one or two of the shaded trees died during the period of intense heat, and only a very small percentage of the lateral branches of the rest of the trees exhibited symptoms of drying.

This comparison of growth in sun and in shade indicates that Caracolillo succeeds better in the open sunlight than any of the other varieties. From experiments so far conducted this variety can be recommended for the elevation of the college farm in preference to any of the *arabica* group.

Bukobensis.—Bukobensis is a *robusta* coffee. Many authorities agree that this type of coffee does not suffer much from intense heat. As shown in Table II, this type of coffee has the greatest increase in growth under all conditions of shading. Since the general tendency of this type is to become a tree rather than a stout shrub, the main stem generally grows much faster than its branches. In growing, it runs up quickly and then ceases to increase for a time, unlike coffees of the *arabica* type, which have a constant, though less rapid, rate of growth.

The Bukobensis variety responded markedly to change of conditions. In the shaded plant the main stem grew faster than the main stem of the unshaded, but the branches of the former behaved in an opposite manner. The branches in the sun had an average increase greater than the branches in the shade. The most active growth took place from the beginning of the experiment (May 20th) to the middle of June. In the months following, in general, no increase was observed until the latter part of August to the middle of September. In some plants, however, the growth began May 20 and continued till the middle of July. About September these same branches grew again, and then stopped until the beginning of December. During this month a comparatively small increase in growth was observed on plants growing under quite favorable conditions. Some shaded trees grew from the beginning of June to September, while others grew only during June.

WORK ON THE MOUNTAIN

On the mountain eight varieties, of three distinct types—*arabica*, *robusta* and *liberica*—were studied. The *arabica* type consisted of Caracolillo, Malaybalay, Jamaica, Ceballos, and No. 730 Arabica; the *robusta* type, Bukobensis and Canephora; and the *liberica* type, Dybowskii only. They were planted in June and July, 1914; and in May, 1916, when the experiment began, they were about two years old from trans-

planting. All these varieties grown on the mountain were of the same age as those in the lowlands, both lots having been planted in June and July of 1914. The same method of selecting plants on the lowland for observation was used on the mountain. The plants were labeled according to location as to shade or exposure to the sun.

The following table shows the number of plants observed under each condition.

TABLE III

Variety	*Shaded*	*In Sun*	*Total*
Caracolillo	10	10	20
Malaybalay	10	10	20
Jamaica	10	10	20
Ceballos	10	10	20
730 Arabica	10	10	20
Canephora	4	4	8
Dybowskii	5	5	10
Bukobensis	10	10	20
TOTAL	69	69	138

These plants were observed and measured in the same way as the plants in the lowlands.

The coffee plantation on the mountain has an elevation of approximately 335 meters. The temperature runs from 22° C. to 30° C. in the shade and from 22.5° C. to 32° C. in the sun, which is much lower than on the lowlands plantation. This elevation and temperature approach what is generally stated as required for coffee in many other parts of the world. The soil is very rich, containing much vegetable matter. Rainfall is quite frequent and the climate may be called cold. The shade trees are high, running from fifty to one hundred fifty feet. The borders are thick forest and the plantation receives the rays of the sun from about eight or nine o'clock in the morning till three to four o'clock in the afternoon. The conditions found here are favorable to the growth of Arabian coffee. Weekly measurements began May 21 and continued to February 25. Since it was impossible to do the measuring in the lowland and on the mountain at the same time, the measurement on the mountain was taken on the day following the measurement in the lowland. The record of temperatures was made on the day of measuring and was taken hourly.

Table IV shows the summary of growth records from May 21 to February 25.

TABLE IV

SUMMARY OF GROWTH RECORDS
MAY 21, 1916, TO FEBRUARY 25, 1917
MOUNTAIN PLANTATION
ELEVATION—APPROXIMATELY 335 METERS.—(Measurements are in millimeters)

Variety	*Average increase in diameter per plant*		*Average increase in main stem growth*		*Average increase in branch growth per plant*		*Date of most active growth*		*Date of stoppage of branch growth*	
	Shade	*No Shade*	*Shade*	*No Shade*	*Shade*	*No Shade*	*Shade*	*No Shade*	*Shade*	*No Shade*
Ceballos	7.04	7.28	232.4	215.5	219.22	189.2	May and June	May and June	Middle of October	Beginning of October
Jamaica	5.68	6.79	234.	344.9	187.59	219.37	"	"	Towards the end of Oct.	"
730 Arabica	8.80	7.43	406.	335.3	266.29	222.876	"	"	Middle of October	"
Malaybalay	4.88	6.73	196.2	249.4	193.68	200.92	"	"	"	"
Caracolillo	7.10	5.89	260.1	281.8	223.43	196.8	"	"	End of Oct.	Middle of Oct.
Canephora	9.0	11.3	264.5	395.0	203.5	358.8	"	"	Middle of October	" "
Bukobensis	6.9	8.71	192.1	214.6	170.95	219.14	"	May, June and August	Beginning of of October	Beginning of October
Dybowskii	9.52	4.88	352.4	258.4	151.7	134.44	"	May and June	Middle of October	Middle of October

Ceballos.—This variety is located at about the middle of the plantation where more sunshine is received than in the case of the other varieties. From Table IV we can see that this variety does better under shade.

The most active growth occurred in the months of May and June, which case is also true of all the other varieties under observation, both shaded and unshaded. In the sun the increase in growth lasted till about the last of September, or the beginning of October. The increase in growth was not constant. At about the middle of June, and from the end of July to the middle of August and towards the end of September there was comparatively little growth.

From the cessation of the growth of the main stem in October till the middle of November no growth was observed in the branches. From the beginning of January there was some growth in the whole plant but none after this month.

In the case of the weak plants that did not possess enough resistance to heat the lower branches gradually died. The greatest death rate of branches occurred about January. There were no cases on record of death of the entire plant.

Among shaded plants, growth lasted till about the middle of October, a period somewhat longer than in the unshaded plants. A slight increase in growth occurred from near the end of June to the middle of July and again towards the end of September. Growth at about the middle of October was the slowest and finally during that month the growth of the season stopped. In a few plants, growth was again noticeable in the latter part of November till the end of December; this again began near the end of February. The most frequent death of branches occurred about the end of December and during January.

Malaybalay.—This variety responds distinctly to the different conditions of shade and sunshine. For this variety, at this elevation, shade is apparently unnecessary. There was a considerable increase in diameter in the open. The main stem had a faster growth in the open, but the branches showed no difference.

The most active growth occurred during May and June both under shade and in the open. Under shade, growth ceased by the middle of October. The growth rate diminished toward June, July and August. The growth of some branches increased in January and February; whereas others either stopped growing or died. Death of branches occurred most commonly in December, but the main stem continued in active growth. In some cases the growth of the main stem was checked in August, October and November.

The greatest increase in diameter occurred when there was most rapid growth of branches. In the open the most active growth occurred in May and June. Growth ceased at the beginning of October, the beginning of the decrease occurring towards July and August and again towards the end of February. The death of branches occurred in December.

Jamaica.—Comparing the growth of this variety with the growth of Ceballos and Malaybalay under shade and in the open, one would be likely to conclude that Jamaica is better adapted to the conditions on the mountain. Though the most active growth occurred in the same months as in Ceballos and Malaybalay, the difference lies only in the rapidity of growth.

Jamaica is better adapted to culture in the open than in the shade at this altitude. The growth under the two conditions showed a difference of approx-

imately eleven centimeters in favor of the former. The increase in diameter was greater in the sun.

The most active growth of the main stem and branches occurred during May and June. In the case of shaded plants, it lasted until the end of October; of the unshaded plants, till the beginning of October. Some plants grew again during part of December and also the latter part of February. The death of some branches occurred in November, December and January. The decrease in growth of unshaded plants began about the beginning of July and continued until September. Increase in growth occurred again at about the end of December and the beginning of January, stopping in the later part of the month. Growth began again near the end of February. Death of some branches occurred in November and December.

Caracolillo.—This variety responds readily to different conditions of shading and exposure to open sunlight. It was planted along one side of the plantation, where it received the least amount of light of all the other varieties.

The growth of the main stem in the open was faster than that under shade. On the other hand, the diameter under shade increased faster than the diameter in the sun. In the shaded plants the growth of branches is greater than in the unshaded plants. Not all the varieties of *arabica* were found to have the increase in growth of main stem and branches directly proportional to the increase in diameter of the stem. The tendency of the plant is to produce wide-spreading branches rather than tall, slender stems.

As was the case with varieties described above, the most active growth was in the months of May and June, both in shade and in the open. The stoppage of branch growth under shade occurred about the end of October and that in the open, about the middle of October. Under shade growth diminished towards the end of June till the end of July, and also in October. There was an increase again of growth in December and at the end of February. The death of some branches occurred in January, though very few died. After the branches had ceased to grow, the main stem still continued its normal growth.

In the open the growth diminished towards the end of June till the middle of July and again towards the end of September. The plants under these conditions lost more branches. Death of branches occurred in the months of October and November. Some branches grew again in December and also about the end of February.

Arabica No. 730.—This variety, as well as Jamaica, was located in the middle of the plantation quite exposed to the direct rays of the sun. Among the varieties of *arabica* that received direct sunlight, Jamaica and Arabica No. 730 received the greatest amount.

According to the result of observations on all the five varieties, the growth of the main stem and branches of Arabica No. 730 was the greatest in the open. It showed, however, an apparent increase in diameter under shade over the growth in the open. The fact that it grows better under shade, seems to indicate that shade is favorable to this plant under local conditions of soil, moisture, and temperature. The most active growth under shade and in the open occurred in May and June. The continuous growth lasted until the middle of October in shade, and in the open until the beginning of October. Under shade the rate of growth ceased to increase about the middle of June, and again toward the end of July and September. The rate of growth of

some plants again began to increase in December and toward the end of February. Though many branches stopped growing and some died, the main stem continued to grow. The death of branches occurred during December and January. In the open growth diminished toward July and September. It is true of all varieties of *arabica* that by the time the branches have completely ceased to grow the main stem still continued to grow very rapidly. During December, more branches died in the unshaded trees than in the shaded.

Bukobensis.—This variety is of the *robusta* type. This type of coffee is very resistant to intense heat. As shown in Table IV, the growth in the open of both main stem and branches is greater than under shade. This shows that under these conditions and at this elevation this variety needs no shade. The most active growth under shade occurred during May and June, and that of unshaded plants, during May, June and August. The stoppage of growth of the branches occurred about the beginning of October. In the open, the majority of the plants had the smallest growth at the beginning of October. Soon after, growth completely stopped and no further growth was observed up to February 24th. In this species of coffee, the larger the growth of the branches and stem, the greater the increase in diameter. In shaded plants the growth of a majority ceased to increase about the middle of August, and from October there was a complete stoppage of growth until December. From the beginning of December to the end of February there was an increase.

Canephora.—This is another of the *robusta* type which seems to need no shade. There is a very great difference between the growth of the shaded plants and the unshaded in diameter and in length of main stem and branches, although the date of most active growth occurred at the same time—May and June. Under both conditions growth stopped at about the middle of October. In the sun, from the beginning of these observations up to the middle of October, there was a continuous growth of main stem and branches. From this time on, there was a complete stoppage in growth, but they grew again about the month of February. In shaded plants the growth did not increase after the end of June up to the end of August and from the end of October till the close of the observations. Some branches did not grow any more after July. This shows a bad effect of shade on growth in this variety.

Dybowskii.—This variety is of the *liberica* type. Though the leaves are thick and apparently resistant to intense heat, yet at this elevation it seems to require shade. Under shade it grew more in diameter, main stem and branches. The date of most active growth was May and June, both in shade and in the open.

In shade growth diminished from July up to August. The complete stoppage of growth was from the middle of October till the end of December, and from that month up to February some growth was again noticeable either in the main stem and the branches, or in the main stem alone.

In the sun, growth diminished from the middle of June up to the middle of August, and until the middle of September. From this time up to the end of the present observations, no increase in the growth of the branches was recorded for most of the plants, but the main stem continued to grow. Results of all growth observations on this variety seem to indicate that it is not well adapted to this elevation.

WORK ON THE PLATEAU

This region has an elevation of about 92 meters. Formerly this was a young forest and the trees ran from 8 to 11 meters high. Beneath the trees, be-

fore the land was cleared, there were thick bushes and vines. The soil is shallow, mostly sandy loam mixed with adobe rock clay loam. The entire plantation is exposed to the easterly winds. To the north and east sides are rivers and ranges of low hills covered with thick forest. The southern boundary is Mount Maquiling.

The temperature under shade runs from 22.8° C. and in the open, from 24° C. up to 31° C. The observations on growth were made on seedlings of two distinct types—*robusta* and *arabica*. The *robusta* type consisted of Canephora (C. A. 5493), *robusta* (C. A. No. 5492), Quillou (C. A. No. 5485), Congensis (C. A. No. 5488), *madagascariensis* (C. A. No. 5494), and *uganda* (C. A. No. 5484). The observations began September 16th, 1916. They ought to have begun earlier, but the seedlings were transplanted too late.

From each variety 10 seedlings under shade and 10 seedlings in the open were selected. The exposed seedlings received full sunlight from morning to afternoon, unlike the unshaded plants on the lowland on the mountain where sometimes they could receive sunlight only at noon. Measurements were made weekly, from a fixed point—a stick driven deep into the ground near the plant. Since the seedlings have almost uniformly cylindrical stems, only one measurement was made on the diameter and this was also taken weekly.

Table V shows the summary of growth records of seedlings at this elevation. The table shows the wide variation in the response of the different varieties to local conditions at this elevation. Although most of the varieties under observation were of the *robusta* species yet some did better in shade and others did not.

Uganda.—Uganda was the poorest of all the varieties in increase in diameter and in the length of stem under shade and in the open. It was transplanted on September 19 and the measurement began October 21. By the time the observation began, thirty-two days after transplanting, it was supposed that the roots were already well established in the soil.

TABLE V

SUMMARY OF GROWTH RECORDS OF SEEDLINGS
FROM SEPTEMBER 16, 1916, TO FEBRUARY 24, 1917
AT MEDIUM ELEVATION—92 METERS.—(Measurements in millimeters)

Variety	Average increase in diameter per plant		Average increase in main stem growth per plant		Date of most active growth		Out
	Shade	No Shade	Shade	No Shade	Shade		
Canephora	0.48	0.493	195.9	187.6	January		November.
Robusta	0.4721	0.6126	169.6	315.2	Nov. and beginning of Dec.		December and January.
Quillou	0.688	0.7764	228.3	250.5	December		December and beginning of January.
Congensis	0.3949	0.5595	161.2	315.1	January		December and January.
Madagascariensis	0.5784	0.7152	203.7	276.3	January		December and January.
Arabica	0.3929	0.4409	237.0	300.5	October to middle of November		December.
Uganda	0.2084	0.3522	76.6	155.9	December		December.
SUMMARY OF GROWTH RECORDS OF SEEDLINGS ON THE MOUNTAIN							
Robusta	0.4209	——	286.2	——	November		
Canephora	0.3167	——	161.6	——	November		
Congensis	0.2460	——	229.9	——	November and December		
Quillou	0.258	——	132.6	——	November		
Uganda	0.1892	——	94.7	——	December		

Under shade the most active growth occurred in December. There was less growth about the middle of November. The decrease in growth occurred from the end of December to the end of the experiment. During that period, some plants were found to have completely stopped growing. In the open the most active growth occurred in December. The growth from the beginning of the observation to the end was continuous, with few exceptions, and the smallest growths recorded were observed during the month of January. It was observed also that the increase in diameter was greater in sun than in the open. Referring to the table, it can be seen that the growth of unshaded seedlings is double that of shaded seedlings. It follows that shade is not necessary to this variety under these conditions at this elevation.

(5493) Canephora.—This was transplanted August 15th, 1916, and observation began 31 days after transplanting. By this time the roots were well fixed in the soil.

In the shade the most active growth occurred in January. The smallest increase occurred in February. There was continuous growth from the beginning to the end of the observations. In the sun, the most active growth occurred in November. The growth was also continuous and the slowest growth occurred toward the end of February, as with shaded seedlings. The difference in the increase in diameter, as well as in the length of the stem, under the two conditions was not large enough to warrant making conclusions as to whether shade is necessary or not.

(5485) Quillou.—This variety was transplanted August 10th and observation began thirty-six-days after transplanting. By that time the growth of the plant was apparently normal.

In the shade the most active growth occurred in December. The least rate of increase occurred in February. In the sun the most active growth occurred in December and the beginning of January. The smallest increase occurred in February. Under this condition this variety has a longer period of activity than in the shade. There was also an apparent difference in the increase in diameter in the open and in the shade. This showed that shade is unnecessary at this elevation.

(5494) Madagascariensis.—This was transplanted August 17th and observation began twenty-nine days after transplanting. Under shade the most active growth occurred in January. In all other months the growth was somewhat uniform. In the open the most active growth occurred in December and January. Towards the end of February a very slight increase was observed. The growth of seedlings in the open is greater than in the shade both in diameter and stem. It is then safe to assume that shade is not at all necessary to this variety.

(5488) Congensis.—This was transplanted August 24th and observation began twenty-two days from transplanting.

Among the *robusta* types that were under observation Congensis is next to Madagascariensis in rapidity of growth in the open. As shown in Table V, the growth in the open is nearly twice that under shade. The increase in diameter in the open is much greater than that under shade.

The most active growth in the sun occurred in December and January and that under shade occurred in January. The increase in growth under shade from the beginning of the observations up to the end of October and during December was low. In February the growth was still lower and some seedlings were observed to have no growth at all. In the open the growth

during September to the middle of October was lower than the growth during the months of November, December and January, to the end of February. How resistant this variety is to heat is very apparent.

5492 Robusta.—This was transplanted July 29th and observation began after forty-seven days. Of all the varieties, this was planted the earliest, so that by the time the observations began it was already well started in the new conditions and the root-systems were well established.

Robusta is very similar to Congensis in the way it reacts to local conditions. However, there was a slight difference and this difference was probably due to the early transplanting of Robusta which exhibited earlier normal growth than the other. According to the result of these observations, so far as growth is concerned, this appears to be the variety best suited to local conditions of all those tried in this region.

In shade the most active growth occurred during November and the beginning of December. The least increase occurred towards the ends of September and December. In sun the most active growth occurred during December and January. The increase in growth was continuous from the beginning to the end of the observation, with the exception that toward the end of September, growth was low as compared with that of the preceding months. Growth in the open was very much greater (nearly twice) that under shade. The increase in diameter showed also a considerable difference. It is then seemingly safe to conclude that shade is not needed at all with this variety at this elevation.

5597 Arabica.—This is the only variety of this type that was under observation. It was transplanted September 4th, 1916, and observations began after twelve days. The growth in the open was greater than in the shade. The increase in diameter showed also an obvious difference so that at this elevation this variety seems to need no shade. The most active growth under shade occurred from October to the middle of November. The least increase occurred in the month of December. There was continuous growth from the beginning of the observations to the last part of November. Slower and irregular growth occurred during the months of November and December and then ceased from the middle of January to the end of February.

OBSERVATION ON SEEDLINGS ON THE MOUNTAIN

The seedlings under observation on the mountain all belong to the *robusta* type. They were planted along the borders of the old coffee plantation where the elevation is the same. They are fully shaded by forest trees throughout the day, on account of which condition they never receive direct sunlight. The same method of measuring the seedlings on the plateau was used on the mountain. As no seedlings in the open could be secured from among the mountain seedlings, only those under shade formed the basis for comparison. It was the object of the observations on these shaded seedlings on the mountain to compare their growth with those of the shaded seedlings on the plateau.

Ten seedlings from each variety were measured. These were: 5492 Robusta; 5484 Uganda; 5485 Quillou; 5498 Congensis; and 5493 Canephora.

From transplanting to the time the measurements began, September 17, they were of the following ages:

Robusta	76 days
Quillou	90 "
Congensis	90 "
Canephora	76 "
Uganda	83 "

Table V shows the summary of growth records of seedlings on the mountain plantation completely under shade. The most active grower was Robusta. Next to this variety was Congensis. The poorest was the variety Uganda.

5492 Robusta.—The most active growth occurred in November. After the measurements began, there was continuous growth which decreased toward the end of February. This variety was observed to be the most active grower.

Congensis.—The most active growth occurred during November and December. Some plants had a continuous growth, though the increase was small; others completely stopped growing after January. In September there was little increase.

5493 Canephora.—This variety was next to Congensis in the way it reacted to different conditions. The most active growth occurred in November. At the beginning of the observations, that is, towards the end of September and from January up to the end of February the increase in growth was comparatively low.

5485 Quillou.—The growth from the beginning of October to the end of December was better than at other times during the experiment. The most active growth occurred in November. Toward the end of September and from January to the end of February the growth was comparatively low.

(5484) Uganda.—From October to the end of December the growth was continuous, the most active growth occurring in December. Growth of the majority of plants completely ceased from the middle of January to the end of February.

The general statement made of all varieties at this elevation as to the increase in the diameter is also true in this case. When there is active growth, there is an evident increase in diameter. Some plants in which the stems lengthen rapidly show small increase in diameter of stem. Such plants as these are found in very heavy shade and generally they are weak and slender.

It still remains to be proved whether the rapid development of certain of these young coffees warrant the establishment of plantations in this locality. In other words, the relation between early rapid growth and productivity in later stages of the plant should be thoroughly investigated. This work is now in progress at the college.

SUMMARY

1. The observations on the mountain among five varieties showed a very clear difference in growth. Robusta had the most rapid growth of all the varieties of the species of the same name under shade at an altitude of about 335 meters. It seems to be well adapted to the conditions of soil, climate and temperature at this elevation.

2. On the plateau, among the Robusta types that grew the best under shade were Madagascariensis, Quillou and Canephora. In the open the best varieties were Robusta, Congensis, Madagascariensis and Quillou. Next to Quillou is Canephora. The lowest growth recorded was obtained from Uganda. By comparing the growth results at altitude of 91 meters and that at 335 meters, Robusta and Congensis show equal success. Among the Robusta varieties that can be grown successfully on the plateau are Canephora and Quillou.

3. Arabica 5597 can be grown successfully at both elevations.

Summarizing the growth records of plants grown on the lowlands and on the mountain the following results are obtained:

4. On the lowland the varieties that grew best under both conditions were

Caracolillo of the *arabica* species and Bukobensis of the *robusta*, the latter being the best. Under shade Malaybalay is next to Caracolillo, while Jamaica and Ceballos are about equal. In the open Ceballos is next to Caracolillo, Malaybalay comes next, and Jamaica is the lowest.

5. On the mountain the best results were obtained from Arabica 730 under both conditions. Others, including *robusta* and *liberica* types can be grown successfully under variable conditions at this elevation.

Under shade the following are given in the order of superiority:

Dybowskii (*liberica* type)
Cenephora (*robusta* type)
Caracolillo (*arabica* type)
Jamaica
Ceballos
Malaybalay
Bukobensis (*robusta* type).

In the open:
Canephora.
Jamaica.
Caracolillo.
Dybowskii.
Malaybalay.
Ceballos.
Bukobensis.

Comparing the growth of some varieties in the lowland and on the mountain, there was found a very great difference in the response to conditions at these two elevations. This is due to frequent rainfall, high elevation, low temperatures and the rich soil of the mountain plantation.

6. The higher the elevation the lower the mean temperature.

ACKNOWLEDGMENT

In closing, I desire to express my thanks to Prof. C. F. Baker for valuable advice and criticisms during the progress of the work; to Prof. E. B. Copeland for his criticisms and suggestions; to Dr. F. T. McLean for supplemental outline of the work and to Graduate Assistants Luistro and Mendiola for their suggestions in connection with the work.

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A Study of Dioscorea with Starch Determinations and Cooking Tests

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Thesis presented for graduation from the College of Agriculture, No. 89.

INTRODUCTION

The yams comprise over 150 distinct species of very wide distribution, but of these, only about 10 or 12 are of importance as food. It is probable that three-fourths of the varieties in cultivation are included in not more than five or six species. (1) The true place of yams among root crops as an article of diet is as yet a debatable one, but in Porto Rico they rank second only to the sweet potato. In countries where they are grown, they furnish the cheapest source of carbohydrate food throughout the greater part of the year. According to Nicholls (2) "they are very nutritious; more so, it is claimed, than the common potato." They are cooked in various ways, either singly or in combination with other foods. When used as vegetables, they are boiled, roasted, fried, baked or cooked in other different ways, like potatoes. A sort of flour is also made from them which can be used in a variety of dishes and forms an excellent breadstuff. They are the chief substitute for potatoes in the tropical countries; for in flavor, texture, and appearance, some of them compare favorably with the latter.

The work presented in this paper may be grouped into two main divisions, namely:

I. (a) Starch determinations of all varieties used, before, during and after maturity.
   (b) Analyses of 12 representative varieties at maturity.
II. The comparative cooking and eating qualities of the varieties used.

In the present work, particular attention is given to the starch content, for it is this constituent which makes up the bulk of the solid material of the root and it is the constituent for which they are specially grown. The relative amount of starch as affected by age was also studied, for this will give information as to the approximate age for harvesting and as to the proper period of storage.

The relative starch content of yams, as well as their palatability, has a great bearing on their value as food. A high percentage of starch combined with good flavor, odor, color, and texture will satisfy the tests, as well as give one of the nutrient elements sought for in foods.

While chemical analysis gives us an approximate knowledge of the relative values of the constituents of food, and hence of its nutritive value, yet, it does not tell us of such physical characteristics as color, odor, and flavor which are as important as nutritive value in food articles. Of course, texture of the cooked product is closely related to chemical composition of the tuber, for a root which is low in starch and in water content will produce a soggy or watery cooked tuber, while, on the other hand, one that has a high percent of starch with less of water will show a mealiness when cooked. It is therefore only through actual test with the palate that their desirability as food is finally determined.

YIELDS OF THE DIFFERENT VARIETIES OF YAMS USED

Yams are considered heavy yielders. It is somewhat difficult to compare the yield in terms of kilograms per hectare with that of other root crops, for, as far as can be found, no accurate data on yield per hectare have been determined in any country. So far as individual yield is concerned, reports from various

sources show that one plant gave as much as 60 kilograms of edible roots, although this is supposed to be the result of two seasons' growth. (3) This may have been an exceptionally heavy yielder. A yield of from 10 to 25 kilograms per plant is not an uncommon occurrence in many varieties especially the "water yam," or "ubi" (*D. alata*). The amount of yield fluctuates materially in different species and in individuals of the same species and is influenced by such factors as climate, soil conditions, cultural management and age.

The following table shows the results of a preliminary experiment conducted in this college on *Dioscorea*, which were planted in rows of one variety each, thus comparing yield under the same treatment.

VARIETIES USED WITH RESPECTIVE YIELD IN KILOGRAMS PER HECTARE

College Number	*Scientific Name*	*Common Name*	*Yield in Kilogram per plant*	*Computed Yield in Kilograms per Hectare*
88-B	*D. aculeata*	Tugui	1.845	8201.84
331	*D. hirsuta*	Calut or Nami	1.786	7936.98
1101	*Dioscorea* sp.	Aparri or Tugui	.848	3768.51
938	*D. alata*	Balibaran Ubi	.594	2639.73
942	*Dioscorea* sp.	Tugui	.629	2795.27
957	*Dioscorea* sp.	Tubayan	.529	2350.87
953	*Dioscorea* sp.	Kinahoy na puti	.742	3300.11
1098	*Dioscorea* sp.	Aparri or Tugui	.463	2057.57
943	*Dioscorea* sp.	Bal-lolong	.521	2315.32
952	*Dioscorea* sp.	Laghitan	.982	4365.34
959	*Dioscorea* sp.	Kinahoy na Puti	1.027	4566.65
1561	*Dioscorea* sp.	Ubing-labok	1.365	6066.06
956	*Dioscorea* sp.	Tinugui	2.445	10865.58
88-S	*D. aculeata*	Tugui	.879	3908.49
329	*D. alata*	Binaksan ubi	.819	3639.63
1103	*Dioscorea* sp.	Corot (unknown)	1.753	7790.33
958	*Dioscorea* sp.	Sinanto	.554	2461.97
1560	*Dioscorea* sp.	Kiriwe	.709	3153.46
1369	*Dioscorea* sp.	Ubing-ligao	2.431	10803.36
960	*Dioscorea* sp.	Dinaliri	.393	1746.49
1095	*Dioscorea* sp.	Ubing-tumuktok	.308	1363.75
962	*D. alata*	Ubing-hinaligui	.448	1992.68
330	*D. alata*	Ubing-kinampay	429	2797.05
2612	*Dioscorea* sp.	Bal-lolong white	.291	1293.20
940	*D. alata*		.329	1462.07
954	*Dioscorea* sp.	Tinugui	.786	3492.98

CLASSIFICATION AND DESCRIPTION OF YAMS—DIOSCOREA

Because of the unsystematic method of popular nomenclature and because of the great variability of the plant, especially of the tuber in different conditions of environment, there arises a great confusion in naming and the same species may be known in different places under different names. Generally, the natives divide the yams into two main groups, namely, *ubi* and *tugui*, the former having sagittate leaves with shiny surface and with four-angled or narrowly winged stems, free from spines, and the latter having orbicular, acuminate, deeply cordate leaves with stems not angled but covered with spines.

They have, however, a separate term for the trifoliate yams with prickly stems and possessing yellow flesh. This species is called *nami* and is the only known poisonous species in the group. The penta- and hepta-foliate species are called *lima-lima*.

It is to be noted that these are but general terms, and when a special variety is meant, another word which tells of the chief characteristics of the variety is added, as for example *ubing ligao*, meaning wild *ubi*, *ubing hinaligui*, meaning post-like yam, because of its

long tuber; *ubing dinugo*, which means blood-like yam because of its blood-colored flesh.

Merrill, (4) in his *A Flora of Manila*, classifies the yams as follows:

I. Leaves simple.
  1. Stems 4-angled or 4-winged.....(1) *D. alata* (*ubi*).
  2. Stems terete, not at all angled or winged.
    a. Unarmed, glabrous, leaves 7- or 9-nerved, ovate slenderly acuminate.....(2) *D. bulbifera*.
    b. Somewhat spiny, pubescent; leaves orbicular to reniform 11- to 15-nerved....(3) *D. fasciculata* (*tugui*).

II. Leaves 3-foliate; stems spiny.....(4) *D. daemona* (*nami*)

III. Leaves 5- or 7-foliate. (5) *D. pentaphylla* (*lima-lima*).

All of the yams are twining herbaceous vines, smooth or armed, with fleshy tuberous roots. As a rule, they die down each year, allowing the plant to rest during the dry season. The leaves have longitudinal veins, either entire, lobed or digitately 3- to 7-foliate. Small tuber-like structures are often seen on the axils of the leaves of some varieties and these furnish a very easy means of propagation.

The tuberous roots vary widely in size, color of bark, color of flesh, flavor, odor, etc.

The weight may vary from several grams to several kilos while the shape may be round, fusiform, long, forked, irregular, etc. Regularly formed tubers are often met in *tugui*, while the most irregular ones are found in *ubi*.

The root may generally be divided into an outer rough part which corresponds to the bark; a layer next to the skin which varies in thickness and color and known as cortex; and an inner part consisting of the flesh proper, known as medullary rays. The skin and the cortex are the parts removed and discarded in preparing *Dioscorea*, leaving the medullary portion.

The skin varies in thickness, in color and in the extent to which it is covered with hairs. The *tugui* has light-colored skin, usually thin. Some are thickly covered with hairs while others are almost hairless with integument so thin that they resemble the potato. It is among some of the *tugui* that sharp spines are developed at the top portion of the tubers.

The skin of the *ubi* is generally dark-colored, thick and corky. They are less covered with hairs and do not possess spines.

The flesh of *tugui* is white, while that of *ubi* varies from white to dark purple. The *nami* is yellow-fleshed with light-colored skin and plenty of hairs.

Some yams are surface feeders, while others extend thier roots deep down in the soil to almost an indefinite length. This may be due either to the habit of the plants or to soil conditions. The *tugui* bears roots in bunches consisting of many tubers connected by slender, filaments to the base of the stem, while the *ubi* has but one big tuber to each plant.

In all of them, except the *nami*, a sticky, mucilaginous substance is present which is however changed in cooking. They have good keeping qualities and can stay in the ground after maturity, or for several months in storage without sign of decay. This gives to this crop a great advantage over other roots, especially the cassava, which decays within a few days after harvest. They are very resistant to disease and drought and they can grow in any kind of soil in any weather under conditions when most other crops would suffer. There is practically no serious pest, either fungus or insect, which is known to attack the yams.

In storage, if they are not planted at the proper time, they germinate, giving out long shoots as though they were in the field.

PLACE OF YAMS IN THE DIET

In India, (5) yams furnish a great part of the diet of the lower class of people and during scarcity due to drought, even the poisonous ones, *Dioscorea daemona* Roxb. (*nami*), are used —hence the term "famine food". This yam is made fit for food by boiling and soaking in running water, this treatment being repeated two or three times. When not properly done, the tuber causes intoxication and sleepiness. In the Island of Guam, (6) yams furnish a very important source of starchy food and during famine, even the spiny wild yam, *gado*, which forms dense thickets in the forest are extensively used.

Yams, like the ordinary potato, are eaten either baked or boiled, fried, roasted or cooked in a variety of ways. In making ice-cream, the *ubi* (*D. alata*), especially the purple—fleshed variety, is much used to impart the peculiar purple color and give a delicate flavor. In many of the Pacific Islands, (7) they are combined with the rich creamy juice of coconut to form dumplings of various kinds.

Boiled roots of yams are common sights in any market, as they can be eaten alone. At times sliced, boiled, yams are mixed with sugar and coconut to make them still more palatable. The flour made from yam forms an excellent breadstuff and can be substituted for other materials. The species *D. fasciculata* is cultivated extensively near Calcutta in India and is used, not only for food, but also for making starch. This is a type of *tugui* the fecula of which is white, a quality which will enable its being manufactured into starch. (8)

Yams are wholly carbohydrate food with starch as the principal constituent, and for this reason, eaten alone, they form a very one-sided diet. They should therefore be combined with nitrogenous foods, as meat, eggs, fish or legumes, in order to make a more balanced ration.

The fact that yams are not as extensively used for food as the potato, especially by the foreigners, does not necessarily mean that they are less nutritious, for, as will be seen later, their composition compares favorably with the potato and other root crops. That they are less used may be due to their rough coarse appearance and irregular shape which would mean a greater loss in preparing. This alone should not totally bar them from use, for in nutritive value and digestibility, they are about the same as potato and other root crops. In a digestion experiment of various root crops reported from Japan, (9) it was found that 99% of the carbohydrate of potato was assimilated; 98% for the sweet potato and 96% for the yams. With this close digestible-carbohydrate coefficient and with practically the same composition, yams ought to occupy about the same place in the diet and furnish a very cheap and palatable substitute for potatoes.

For the purpose of ascertaining the physical and chemical properties of *Dioscorea*, samples were taken from the field at various times and analyzed chemically. Samples were also cooked and physical properties, such as color, odor, taste, etc., determined before and after cooking. The latter part of this test is reported under the heading "Cooking Qualities of Yams."

METHOD OF SAMPLING AND ANALYSIS

The plants used for analysis were from the same field, planted at about the same time and treated alike. They were planted in variety-to-row test, thus making the area occupied small and eliminating the effect of the dif-

ferences in the nature of the soil on the chemical composition of the roots. It is to be noted that the plants in general were not in the best of condition, as shown by the somewhat poor yield and by the fact that the foliage was less luxuriant than in the case of healthy plants. This may be accounted for by the kind of soil on which they grow, which is a heavy clay.

In this work, three samplings were made, one on September 15, when they were about 6½ months old, the other on November 15, when they were about 8½ months old, and the last one on January 15, about two months after harvest.

The first sampling was done while they were still growing in the field, making it rather difficult to secure representative samples. The best that could be done was to take samples at random from different parts of every row.

The second sampling which was at the time of harvesting was done by taking representative samples from the harvested piles of each variety. Most of them were supposed to be matured by this time for their leaves were turning yellow. Some, indeed, had their leaves dry, but others had green leaves due, possibly, to the difference in time of maturity among the different varieties. The complete analyses discussed later are run on these samples.

The third samples were taken from the stored roots. They had been placed in boxes in a dry room in the chemistry laboratory where they would suffer neither from the hot sun nor from the drying effect of strong wind. By the time of the third sampling, as stated above, shoots were seen developing from some of the roots specially of the *nami* and the *tugui*; some were wrinkled while others seemed to have changed but little in so far as appearance was concerned.

For starch determination, only the flesh was used, the skin and cortical layer being discarded. The amount of starch was determined by the acid hydrolysis method and Fehling's solution, as described on page 53, Bulletin No. 107 (revised) of the U. S. Department of Agriculture. (10)

Moisture, protein, ash, ether extract, and sugars were determined as outlined in that bulletin. (11)

Crude fiber was determined as outlined in the Official Method for Determining Crude Fiber as Applied to Cottonseed Meal by C. K. Francis. (12) This is based on the fact that 3.52% sodium hydroxide (NaOH) solution, will neutralize the acid used and leave 1.25 per cent free alkali in the solution. According to this procedure, one filtration is saved and there is no need of adding an indicator and carefully neutralizing, besides eliminating other possible sources of error.

Table I shows the relative composition at maturity of different varieties of yams grown at the college.

Table II gives the relative composition of some other tropical starch-bearing roots for comparison.

TABLE I
CHEMICAL COMPOSITION OF DIOSCOREA

Coll. No.	Name of Variety	% Water	% Protein	% Fat	Carbohydrates				% Ash	% Undetermined
					% Starch	% Dextrose	% Sucrose	% Crude fiber		
88-B	*D. tiliaefolia*—Tugui	79.49	7.10	1.42	68.46	2.61	11.60	3.17	3.27	2.36
1101	Aparri or Tugui	82.63	6.79	1.67	70.94	2.42	9.20	3.97	3.97	1.04
942	Tugui	70.22	4.53	.44	83.49	1.51	4.31	2.52	3.12	.08
1098	Aparri or Tugui	69.07	5.04	.71	82.30	1.71	4.76	2.52	2.94	.02
88-S	*D. tiliaefolia*—Tugui	76.67	5.54	.47	78.54	1.34	5.92	2.90	5.28	.01
957	Tubayan (Ubi)	71.04	6.25	.51	83.99	.85	.88	2.70	4.71	.11
959	Kinahoy na Puti (Ubi)	67.32	5.23	.80	83.04	.55	1.10	1.99	3.64	3.65
1561	Ubing Labok	75.29	7.36	.73	78.00	1.05	2.06	2.91	4.25	3.64
329	Binaksan Ubi	69.75	6.76	.78	80.47	1.14	1.58	2.15	3.26	3.86
954	Tinugui (Ubi)	76.32	7.97	1.11	76.44	1.86	4.38	3.70	3.85	.60
331	Calut or Nami	78.29	8.31	.74	77.60	1.11	1.57	4.29	3.18	3.20
1103	Calut or Nami	78.13	8.11	.74	77.09	1.16	1.95	3.89	3.25	3.81
	AVERAGE	74.52	6.58	.83	78.36	1.44	4.11	3.06	3.37	

TABLE II

AVERAGE COMPOSITION OF SOME TROPICAL STARCH-BEARING ROOTS (13)

Name of Plants	% Water	Based on Dry Weight					
		% Crude Protein	% Fat	% Ash	Total Carbohydrate % of Starch, sugar, etc.	% crude fiber	Fuel value per lb. in calories
1. Sweet Cassava	66.0	3.03	.59	2.06	88.82	5.29	610
2. Taro	70.9	6.18	.68	4.12	79.73	2.75	475
3. Yams (*Dioscorea*)	72.9	6.66	.74	3.33	86.00	2.22	475
4. Yautia tubers	70.0	7.33	.66	2.99	87.00	1.99	535
5. Potatoes (Irish)	78.3	10.12	.46	4.60	83.00	1.74	375
6. Potatoes (Sweet)	69.0	5.80	2.25	3.55	84.22	4.18	570

DISCUSSION OF THE COMPLETE ANALYSIS OF DIOSCOREA ROOT

From a study of Table I, it is seen that the *Dioscorea* root is largely composed of water, this constituent averaging in the different varieties about three-fourths of the total weight. Thus the amount of water varies in the different varieties and even in individuals of the same variety, ranging from 82.63% or more than four-fifths of the fresh weight to as low as 67.32%, or almost three-fifths. It also varies with age, as will be shown later, the younger and more immature ones containing more water than either the mature or those that had passed maturity.

Protein occurs in small amounts and, like other constituents, varies with the variety. It forms from 4.53% to as high as 8.31% of the dry weight with an average of 6.58%. It also varies according to age, and young roots are said to contain more protein than mature ones.

Fat is present in such small quantity so as to make it almost negligible. In amount it ranges from as low as 0.44%, to 1.67%, with an average of 0.83%. In food and feeding stuff analysis, it is usually designated as "ether extract".

Ash, in which are contained the mineral matters, such as compounds of calcium, iron, potassium, sulphur, etc., is found to be somewhat variable in different varieties. It ranges from 2.94% to 5.28% and with an average of 3.73% of the dry weight.

Next to water, in quantity, comes starch which with sugars and crude fiber forms the carbohydrates, which are more than four-fifths of the dry matter.

The crude fiber, or cellulose, which forms the framework of the root enclosing the starch granules vary in different varieties from 1.99% to as much as 4.29% and with an average of 3.06% of the dry weight.

Sugars, which vary in amount in different varieties, are classified as reducing sugar and non-reducing sugar or sucrose. It was found that most of the sugar present is in the form of sucrose, the per cent of which varies from 0.88% to as much as 11.60%, while the reducing sugar varies from 0.55% to as high as 2.61%. The average for reducing sugar is 1.44% and that for sucrose, 4.11%. It is these constituents which give the slightly sweet taste to some of the roots. It is noted that, on the whole, *tugui* is richer in sugars than either the *ubi* or the *nami*.

Starch, which constitutes the bulk of the dry matter—on the average more than three-fourths—is found to vary in quantity in different varieties from 68.46% to as high as 83.99% with an average of 78.36%.

When we consider that the yams used were treated equally as to the time of planting, spacing, cultural management, and soil, we can assume that this variation in starch content is to a great extent due to the hereditary qualities of the

different varieties for starch deposition. This variation may give a good basis for selection. Of course, in selecting seeds such factors as yield and quality should also be considered.

Variation in starch content may be due to the character of the soil, the climate, and the other conditions under which these plants grow, but age is a large controlling factor in this respect.

As will be seen later, young immature roots are found to contain a relatively smaller starch content than the more mature ones, while those that had passed maturity and are developing young shoots tend to decrease their starch content naturally.

Table III shows the variation of starch and water during a period of four months just preceding and following maturity.

TABLE III

Name	College Number	I September 15 Before Maturity		II November 15 At Maturity		III January 15 After Maturity	
		% Moisture	% Starch	% Moisture	% Starch	% Moisture	% Starch
1. Tugui	88-Big	80.8	62.88	79.49	68.46	75.30	55.37
2. Calut or Nami	331	79.37	72.33	78.29	77.60	78.14	61.62
3. Aparri or Tugui	1101	86.97	50.15	82.63	70.94	76.89	55.50
4. Balibaran Ubi	938	74.57	73.99	71.88	76.83	71.50	69.36
5. Tugui	942	75.72	73.05	70.22	83.49	63.07	65.09
6. Tubayan	957	74.01	79.80	71.04	83.99	66.09	71.66
7. Kinahoy na Puti	953	75.13	77.01	71.48	78.90	71.31	74.91
8. Aparri or Tugui	1098	73.96	73.59	69.07	82.30	64.88	69.99
9. Bal-lolong	943	71.97	76.65	70.38	80.75	69.67	71.39
10. Laghitan	952	75.80	71.93	70.06	82.19	66.92	72.92
11. Kinahoy na Puti	959	67.73	83.09	67.32	83.04	67.18	73.34
12. Ubing-labok	1561	77.06	72.87	75.29	78.00	74.67	66.03
13. Tinugui	956	75.86	72.60	73.69	74.94	66.10	60.36
14. Tugui	88-Small	79.06	72.51	76.67	78.54	71.44	62.07
15. Binaksan Ubi	329	72.13	76.74	69.75	80.47	66.00	70.85
16. Corot—unknown	1103	80.87	75.39	78.13	77.09	75.48	60.14
17. Sinanto	958	77.90	63.87	75.38	76.02	68.88	60.72
18. Kiriwe	1560	74.45	75.84	73.84	78.63	71.99	68.19
19. Ubing ligao	1369	70.14	72.87	67.63	78.36	66.48	72.06
20. Dinaliri	960	75.76	75.48	71.80	83.76	70.10	73.14
21. Ubing tumuktok	1095	74.47	74.89	71.25	78.27	70.00	71.75
22. Ubing hinaligui	962	76.45	73.95	73.54	78.63	71.16	71.16
23. Ubing kinampay	330	70.81	81.02	70.46	81.51	69.73	69.32
24. Balolong white	2612	69.58	82.77	69.31	82.95	68.44	67.77
25. Ubi	940	72.95	76.74	72.00	77.91	69.23	64.55
26. Tinugui	954	78.30	66.48	76.32	76.44	74.00	69.27
AVERAGE		75.46	73.39	72.96	78.84	70.18	67.32

EXPLANATION OF TABLE III

A study of Table III shows that the moisture varies with the variety at each period noted; but that there is on the average a decrease in moisture content from a period of two months before maturity to a period of two months after maturity. Similarly, the percent of starch based on dry matter varies at each period for the varieties, but generally increases to maturity and decreases to a certain extent after maturity.

Two months before maturity, as noted in column I, the maximum water content is about 87% and the minimum, about 68%, with an average of about 75.5%. The starch varies from 50% to as high as 83% with an average of about 73% of the dry weight. Generally, with decrease of water content, we have an increase of starch. This is shown at the extremes in the case of 1101 and 959 which have respectively about 87% of water and about 50% starch and about 67% water and 83%

starch. Exceptions to this general rule, of course, occur, the most noticeable being variety 1103, which is above the average both in water and starch but which is evidently practically at maturity by September 15. Number 1369 is below the average both in starch and water but is one of those which exhibited the least change in starch content of all varieties during the four months' period.

At maturity, as shown in column II, the water varies from about 67%, as minimum, to about 83%, as maximum, and with an average of approximately 73%. The starch varies from 68% to 84% with an average of about 79%. Again, as in the period previous to maturity, there is an increase in starch as the water decreases. This is shown by 88-Big and 959 which have respectively about 80% water and 69% starch and about 67% water and 83% starch. This does not hold in all cases, for 1101, which has a moisture of about 83% and which ought to give a lower percentage of starch than No. 88, has a higher amount.

In column III are noted variations in amount of water from about 63% to about 78% with an average of about 70%. The percent of starch varies from 55.37% to about 80% with an average of approximately 67%. There seems to be no distinct relation between the amounts of water and of starch, such as shown in the two previous columns. This may be due to a rapid loss of water by evaporation accompanying the transformation of starch to sugar and finally to carbon dioxide and water which, of course, are lost by transpiration.

In comparing columns I, II, and III, it will be seen that, as is to be expected, there is a general decrease in moisture content with age. The starch content on the other hand increases to maturity and then decreases markedly thereafter. The largest decrease of moisture content during the first period is that of 952 and amounts to about 6% and the smallest is that of 2612, about 0.3%. During the second period, the largest decrease shown is by 956 with an amount of about 7.5%, while the smallest one is that of 331 amounting to 0.15%. It is to be noted that, as a rule, those which lose more water during the first period are the ones that also lose more water during the second period. The variations in the decrease in moisture content may be accounted for in several ways—it may be due either to a difference in their period of maturity or to the nature of the skin. The less matured ones having more water are likely to lose a proportionally larger amount than the drier mature ones, while the thick corky skin prevents loss of water to a greater extent than the thin skin.

The starch content, as has been mentioned, increases toward maturity. The largest increase is that shown in 1101 and amounts approximately to 20% and the least is that of 2612 amounting to about 0.2%. It is to be noted that 959, instead of making an increase as the others, decreased slightly by 0.05%. As an average, the increase is about 5.5% for the first period. These variations in the increase of starch were caused probably principally by the difference in their maturity.

After maturity, the starch content invariably decreases, the maximum change being shown by 942, about 18.5% while the minimum is found in 953 about 4%. As an average, the decrease for the second period is about 11.5%. These variations in the decrease of starch may be due: (1) To the maturity of the roots at the time they are harvested; (2) to the earliness by which they begin the new growths.

It is of interest to note here that the *tugui* (1101, 942, 1089, 88-Small) and the *nami* (331, 1103) were the first to give new growths and that these varieties, as seen in the table, gave a decided decrease of starch after maturity. The loss is 15.44%, 18.4%, 12.31%, 16.47%, 15.98%, 13.95%, respectively.

As a rule, those which made a large decrease in water made a correspondingly large increase in starch. This is shown by 952 and 2612, the former having a decrease of about 6% water with an increase of 10% starch, while the latter decrease 0.27% water with an increase of 0.18% starch. As has been mentioned before, there seems to no definite relation between moisture and starch changes during storage, the rate of evaporation of water apparently being the process mostly going on at this stage.

There is no doubt that these changes are brought about by chemical and physical processes in the root. Previous to the period of maturity there seems to be a continuous deposition of starch in the root and after maturity a decrease of the starch due to its changing into sugar, which is used in metabolism during growth.

That similar progressions and retrogressions occur in other root crops is shown by the following statement: "In an experiment at 12 different stages of growth of beets from June 10 to December 12, samples were found to begin with 6.62% sugar, and gradually increase up to the 9th of November to 15.8% and then decrease to 13.6% in December." (14)

According to Snyder, (15) plants do not have the same chemical composition at different stages of growth. The chlorophyll and protoplasm are most active in the early stages and produce nitrogenous compounds more rapidly than non-nitrogenous ones, while the latter stages of growth are characterized mainly by the production of carbohydrates, such as starch, and by various chemical and physical changes incident to ripening and transfer of organic compounds. This can be illustrated in the composition of corn plant at different stages of growth.

TABLE IV

COMPOSITION OF DRY MATTER OF CORN PLANT (16)

Stage of Growth	*% of Ash*	*% of Crude Protein*	*% of Crude Fiber*	*% of Sugar*	*% of Starch*	*% of nitrogen, free extract*	*% of ether extract*
Very immature (Aug. 15).....	9.3	15.0	26.5	11.7	——	46.6	2.6
A few roasting ears (Aug. 28).....	6.5	11.7	23.3	20.4	2.1	55.6	2.9
All at roasting stage (Sept. 4).....	6.2	11.4	19.7	20.6	4.9	59.7	3.0
Some ears glazing (Sept. 12).....	5.6	9.6	19.3	21.1	5.3	62.5	3.0
All ears glazed (Sept. 21).....	5.9	9.2	18.6	16.5	15.4	63.3	3.0

It is very evident, as shown in the preceding table, that during the earlier period of growth, there is more of ash, more of crude protein and crude fiber than at the later period. It is also to be noted that the per cent of sugar gradually rises to the maturing period and then decreases rapidly. The starch which has increased gradually up to this stage, shows a more marked increase, evidently at the expense of the sugar.

It is also seen that stored roots, whether mature or immature, lose starch in storage. Besides this, water is evaporated, thus causing shrinkage. The loss of weight is due to the evaporation of water and respiration of carbon dioxide (CO_2), while that of starch may be due to its transformation into sugars and other soluble forms by certain enzymes or ferments invariably present in starchy roots.

The following changes were noted in potatoes during storage, (17) and it is probable that changes of similar nature are going on in the stored yam roots:

1. Sugar accumulates in potatoes at the expense of the starch.

2. Respiration converts starch and sugar into water and carbon dioxide. This is continually going on in stored potatoes, the rate of respiration being influenced by temperature.

3. The rate of respiration is accelerated by accumulated sugar, germinating buds, moisture and light.

4. There is a loss in weight during storage, due to the evaporation of water and respired carbon dioxide. Warm, dry weather favors evaporation.

5. The loss of carbon dioxide is greatest at high temperature. The rate of loss increases with sprouting and warm weather.

6. Starch, sugar, and protein are rapidly depleted in sprouting potatoes.

To further illustrate the changes taking place in stored roots, the following table on the relation of starch to the sugars in potatoes during storage is here reproduced:

CHANGES IN COMPOSITION OF DIFFERENT VARIETIES OF SWEET POTATOES ON STORING (18)

	First Lot—November 28				Second Lot January 7			
Name of Variety	% *Water*	% *Starch*	% *Glucose*	% *Sucrose*	% *Water*	% *Starch*	% *Red Sugar*	% *Sucrose*
Georgia Buck	75.35	53.27	3.14	17.50	69.74	42.04	5.78	30.56
Bunch Yam	72.37	54.71	3.93	16.11	67.31	41.80	6.19	30.22
Bunch Yam	67.99	61.18	1.74	14.04	67.29	42.27	7.34	28.86
Horton Yam	70.29	50.68	3.53	20.98	71.39	33.45	9.00	33.86
Georgia Buck	71.56	50.45	2.58	13.23	67.63	44.57	6.55	24.27
Vineless Yam	70.03	56.22	1.81	16.72	67.33	36.81	8.89	30.88
Hanover Yam	76.16	57.10	4.63	17.70	70.13	47.29	5.57	22.04
Georgia Yam	70.01	62.93	3.32	13.62	71.78	39.72	8.00	28.72
AVERAGE	71.72	55.82	3.09	16.16	69.08	40.99	7.17	28.68

It is seen here that there is more starch in roots at the beginning of storage than at later times. On the other hand there is more total sugar present in the stored roots than in the fresh ones, showing that the starch is not lost directly as starch but is first changed to sugar. It is possible that similar changes take place in stored roots of *Dioscorea*.

COOKING QUALITY OF YAMS

This was determined by boiling and then examining by tasting. The changes before and after cooking were noted and these are included under the following headings:

I. Fresh tubers—
   1. Nature of the skin
   2. Color of cortical layer
   3. Color of flesh proper (medullary)
   4. Amount of sticky substance
   5. Distinctness of fiber when cut, whether distinct, blurred or not visible.

II. Cooked tubers—
   1. Color of flesh
   2. Odor
   3. Flavor
   4. Presence of sticky substance
   5. Texture, whether mealy, soggy, soft, gummy, etc.
   6. Taste, whether sweet, stringy, bitter, etc.

QUALITY AND FACTORS AFFECTING IT

A yam root of good quality should be mealy when properly boiled and should have a good odor and flavor. The color may vary due to varietal characteristics but should not be brown. Yams of poor flavor, or strong odor, or which when cooked show watery or waxy texture with an appreciable amount of sticky substance are considered of poor quality.

Mealiness is one of the most important factors in considering the cooking quality. This mealiness is due to the uniform distribution of abundant starch throughout the tuber. In an extended investigation by Coudon and Bussard (19) on 34 varieties of potatoes, a study including analytical work and cooking tests, it was shown that the firm, soggy nature of boiled tuber was a result of a low starch and a high protein content, while those potatoes which were mealy contained high percentage of starch, ranging from 18 to 20% on the fresh basis.

Like the chemical constituents, the culinary quality may be more or less affected by internal, as well as external, factors. Quality is to a great extent influenced by the relative amounts of water and solid matter present. Tubers which are too watery, usually the immature ones, give a soft and soggy cooked product, while those with a high percentage of dry matter and less of water turn out drier and more mealy.

The nature of the skin and shape of the tuber have an important bearing on the culinary quality. Corky and rough appearance of the skin shows maturity of the tuber and often good cooking quality, while thin smooth skin is an indication of immaturity and thus of poor cooking quality. Age also affects the cooking quality. As with stored roots, the older yams taste sweeter than the fresh ones.

Hairy tubers and irregular formation, such as deep notches or undue prominences, are objectionable for these may carry much dirt, and the labor, time and waste in preparing them for cooking are much greater than if they are evenly shaped. While this is true among most of the yams, there are some which are evenly shaped and, by judicious selection for better forms, there is no doubt that even the ill-formed ones can be made to produce evenly formed roots.

CHANGES IN COOKING

In cooking the changes which take place are both physical and chemical. There is a change in color, flavor, odor, etc. The starch grains which before cooking are inclosed in walls of crude fiber are ruptured and expanded to a mass of less solid structure. The tough cellulose is ruptured, thus releasing the starch grains inside, some of which are disintegrated, others converted into soluble forms of dextrin and some hydrolized. The protein coagulates much like the white of an egg.

The longer the cooking the more moist the root becomes. This is probably due to the changing of part of the starch to soluble carbohydrate by hydrolysis.

COOKING TESTS

88 Big—D. tiliaefolia—Tugui

Fresh tuber: Skin light colored and hairy; cortex greenish; flesh white, quickly turning dark brown when exposed; sticky, mucilaginous substance, very abundant; fiber slightly distinct.

Cooked tuber: Color changes to yellowish and sometimes brownish; taste somewhat sweet; flavor poor, odor poor; very damp and soggy; poor in keeping quality; sticky substance not entirely lost.

1101 Aparri or Tugui

Fresh tuber: Skin very thin and membranous, light colored, hairless and very similar to potato; cortex light brown; flesh white and unchanged when exposed; sticky substance plenty; fiber slightly conspicuous.

Cooked tuber: Cortex tastes slightly bitter; flesh unchanged in color, taste sweet, very soft, and damp with free water; good flavor and odor; a somewhat poor keeper, shrinking very rapidly.

938 Balibaran—Ubi

Fresh tuber: Skin somewhat thick, corky, dark colored with few hairs; cortex purplish; flesh white purplish and turning to light brown; sticky substance plenty; fiber not visible.

Cooked tuber: Flesh light purple at the center and gradually towards the outside; mealy texture; flavor good but not sweet.

942 Tugui

Fresh tuber: Skin light colored, full of cracks and covered with plenty of long hairs; cortex greenish; flesh white throughout turning to light brown; latex plenty; fiber slightly distinct.

Cooked tuber: Cortex slightly bitter; flesh unchanged, being pure white; taste sweet; texture mealy; odor fine and flavor good; some are found to be fibrous and soft.

957 Yam Tubayan

Fresh tuber: Skin grayish dark, corky, and sparsely covered with hairs, cortex yellowish; flesh pure white throughout; sticky substance plenty; fiber not distinct.

Cooked tuber: Color unchanged, being pure white—perhaps the whitest of all ubis; very mealy in texture, with characteristic flavor, that is, very different from most of the others; odor good but not sweet.

1098 Aparri or Tugui

Fresh tuber: Skin light colored, thin and covered with very few short hairs; cortex greenish; flesh white throughout; sticky substance plenty; fiber somewhat distinct.

Cooked tuber: Flesh unchanged in color being pure white; mealy in texture, sweet, somewhat fibrous; odor good; liked by many.

943 Bal-lolong

Fresh tuber: Skin corky, dark colored and almost hairless; cortex purple; flesh white, with very light shade of purple about the center; flesh turning light brown on exposure; sticky substance plenty; fiber not distinct.

Cooked tuber: Flesh purplish, mealy but not sweet; odor and flavor good; fiber and sticky substance absent.

952 Yam—Laghitan

Fresh tuber: Skin somewhat thick, corky, dark colored and sparsely covered with hairs; cortex purple; flesh whitish purple throughout, turning brown when exposed to air; sticky substance plenty; fiber not distinct.

Cooked tuber: Flesh purplish throughout; very mealy in texture; flavor good; odor similar to others, taste not sweet; sticky substance none, fiber inconspicuous.

959 Yam—Kinahoy na Puti

Fresh tuber: Skin corky, dark colored, with very few short hairs; cortex purple; flesh white with very light shade of purple, turning brownish when exposed; sticky substance plenty; fiber not distinct.

Cooked tuber: Changed to lighter purple; mealy and less watery than others; flavor good; odor similar to others, taste not sweet and no fiber.

1561 Ubing Labok

Fresh tuber: Skin dark colored, thinner, and almost hairless; cortex white; flesh white throughout changing to brownish; sticky substance plenty; fiber inconspicuous.

Cooked tuber: Flesh unchanged, being pure white throughout; flesh soft and damp; very slightly sweet; flavor and odor fair.

956 Yam—Tinugui

Fresh tuber: Skin very rough, thick, corky, with plenty of hairs; cortex yellowish; flesh yellowish white throughout, turning dark brown very quickly when exposed; sticky substance plenty; fiber inconspicuous.

Cooked tuber: Flesh yellowish throughout, texture gummy and soft; somewhat bitter and stringy; flavor and odor disagreeable; not a desirable variety.

88 Small Tiliaefolia—Tugui

Fresh tuber: Skin light colored, thin and covered with plenty of long hairs; cortex greenish; flesh white throughout, turning grayish white when exposed; sticky substance plenty; fiber slightly conspicuous.

Cooked tuber: Color changes to dull white and sometimes to brownish; taste sweet; texture soft and damp; flavor and odor good; slightly fibrous; greatly improved by storage.

329 Binaksan Ubi

Fresh tuber: Skin purplish somewhat corky, with very few hairs; cortex bright purple; flesh white inside and purple towards the outside; very slightly changed when exposed; sticky substance plenty; fiber not conspicuous.

Cooked tuber: Color unchanged; texture mealy; flavor good; odor good; fiber none; not sweet.

1103 Corot or Nami—unknown

Fresh tuber: Skin light colored, thin, with plenty of long hairs; cortex greenish yellow; flesh yellow throughout; sticky substance absent; fiber inconspicuous.

Cooked tuber: See 331 Nami.

958 Yam—Sinanto

Fresh tuber: Skin dark colored, corky and sparsely covered with hairs; cortex light purple; flesh white with a light purplish tinge; sticky substance plenty; fiber not distinct.

Cooked tuber: Color of flesh purplish; texture somewhat mealy; taste slightly bitter; not sweet; flavor and odor disagreeable; sticky substance absent; fiber inconspicuous.

1560 Ubi—Kiriwi

Fresh tuber: Skin corky and of a light color, with almost no rootlets; cortex purplish white; flesh pure white throughout; sticky substance plenty; fiber inconspicuous.

1369 Ubing Ligao

Fresh tuber: Very thick, corky, rough and sparsely covered with hairs; cortex yellow and thick; flesh whitish yellow, turning brown when exposed; sticky substance plenty; fiber not distinct.

Cooked tuber: Changed to brownish or yellowish; somewhat mealy; flavor and odor poor; taste stringy; an undesirable variety.

1095 Ubing Tumuktok

Fresh tuber: Skin corky, dark colored with few hairs; cortex purple; flesh pure white throughout, slightly changing to brown when exposed; sticky substance plentiful; fiber inconspicuous.

Cooked tuber: Unchanged in color; somewhat mealy, not sweet; flavor and odor fairly good; fiber not distinct.

960 Ubing Dinaliri

Fresh tuber: Skin corky, dark colored; hairs few; cortex light purple; flesh white throughout; sticky substance plenty; fiber not distinct.

Cooked tuber: Unchanged in color; texture mealy; good flavor and odor fair.

962 Ubing Hinaligui

Fresh tuber: Corky, thick; hairs very few; cortex dark purple; flesh dark purple throughout; sticky substance plenty; fiber not distinct.

Cooked tuber: Flesh darker purple; somewhat mealy in texture; good flavor and odor; not sweet; sticky substance absent.

330 Ubing Kinampay

Fresh tuber: Skin corky, dark colored, with few hairs; cortex bright purple; flesh purplish throughout and unchanged on exposure; plenty of sticky substance; fiber not distinct.

Cooked tuber: Lighter purple; mealy in texture; good flavor and odor; not sweet; fiber absent.

2612 Bal-lolong White

Fresh tuber: Corky, dark colored, sparsely covered with hairs; cortex purple; flesh white with purplish tint, turning brownish when exposed; sticky substance plenty; fiber inconspicuous.

Cooked tuber: Unchanged in color; very mealy texture; not sweet; flavor and odor good.

940 Ubi

Fresh tuber: Skin dark colored with few hairs; cortex purple; flesh white with light tints of purple; sticky substance plenty; fiber not distinct.

Cooked tuber: Color unchanged; somewhat mealy, not sweet; flavor and odor fairly good.

954 Yam Tinugui

Fresh tuber: Skin corky, dark colored, almost hairless; cortex very light purple; flesh white throughout changing to brown; sticky substance plenty; fiber not distinct.

Cooked tuber: Changed to pinkish white; texture damp and soft; slightly sweet; flavor and odor fairly good.

331 D. hirsuta—Nami

Fresh tuber: Skin, light colored and covered with plenty of long hairs; cortex greenish yellow; flesh yellow throughout and unchanged on exposure; sticky substance absent; fiber not distinct.

This variety demands special treatment before it can be safely used, because of the poisonous substance present in it. The tubers are prepared by cutting them into very thin slices and then salting with common salt. These slices are left standing in a close-covered tank over night and the next morning are taken out to be washed, usually in running water. Here they are left for a long time, usually for a day, and then washed over and over again by pressing it until no more whitish substance is seen coming out and no more of the characteristic smell can be detected. By this process, a large amount of the starch and most of the sugars are lost leaving a small amount of the more fibrous material behind. They can then be cooked and safely served. They can be dried and ground and when so prepared are pure white and look like the best wheat flour. When prepared properly, *nami* is preferred to other yams, but in the hands of a careless preparator, it smells bad and causes vertigo and drowsiness. The lower animals are also affected when fed with improperly prepared tuber.

Lime can also be used to help remove the poisonous principles in the *nami*, but common table salt is preferable

because more easily available in the kitchen. It is probable that future study may find an easier and more effective way of eliminating the poison without so great a loss of starch.

The following varieties were secured from the barrio of San Antonio. These are more or less wild.

Lima-lima

Fresh tuber: Skin light colored, thin and covered with plenty of long hairs; flesh white, quickly turning brown when exposed to air; sticky substance very abundant; fiber slightly distinct.

Cooked tuber: Color unchanged; texture very soft and damp with plenty of sticky substance; flavor and odor poor; a very undesirable variety.

Paket

Fresh tuber: Skin dark colored with few hairs; cortex brownish; flesh pure white throughout; sticky substance plenty; fiber not distinct.

Cooked tuber: Flesh unchanged being pure white; very mealy and somewhat drier than others; flavor and odor characteristic; very much desired by the natives.

Tuguing Puló

Fresh tuber: Skin light colored, covered with short hairs; cortex greenish; flesh white, quickly turning brown when exposed; sticky substance very abundant; fiber somewhat distinct.

Cooked tuber: Changed to dull brown; taste slightly sweet; texture soft, damp, sticky substance present; poor flavor and odor; not a desirable tuber.

It is thus seen that there is a close relationship between the starch-content and the texture of the cooked tuber. As a general rule, mealy and dry tubers are found to be higher in starch while those which are soggy and soft are found to be those of low percentage of starch. This is well illustrated by 88-Big, 1101, 88-Small, 954, which are practically soft when cooked and which on analysis show a comparatively low percentage of starch, while 959, 1098, 957, etc., are mealy and somewhat dry when cooked and which on analysis show a high percentage of starch.

Those which show a high percent of water content and, as has previously been pointed out, are usually poor in starch, are soft when cooked, while those with less water content produce a drier meat when cooked.

Analysis show that those which are soft and soggy contain practically a higher percentage of protein, while the more mealy ones are those with less protein. It will also be noticed that the *tugui* are higher in sugar content than either the *nami* or the *ubi* and this accounts for their being sweeter than others.

As a rule, cooking eliminates the sticky mucilaginous substance present in nearly all of the yams in the fresh state. There are, however, a few cases where it is not totally eliminated. This does not occur in the varieties high in starch but only those which are poor in starch. This sticky mucilaginous substance when present in the cooked tuber makes it very undesirable for food.

Generally, cooking does not materially change the color of the tuber. Slight to marked changes however were found in some. Thus 88-Big, which while fresh is white, turns yellowish or brownish when cooked.

Flavor, odor and taste are greatly developed through cooking. While almost inedible when fresh due to the peculiar flavor, odor and taste, they become very much improved by cooking, which makes many of them excellent articles of diet.

Fibers do not seem to be conspicuous in yams. It is only among some of the *tugui* that they are slightly visible.

It is noted that flavor, odor and taste are not correlated with the per cent of starch. Good flavor and starch content are independent of each other and may be found in those with low starch content as well as in those high in starch. As examples, 1101 is a poor starch yielder, yet its flavor and odor are good and the taste sweet; 1369 and 956 are higher in starch but of very poor flavor, and bitter and stringy in taste so that they are of little value as food. High starch content alone will not recommend a yam for food. The cooking qualities depend upon a good combination of fine flavor, odor and pleasant taste with a high starch percentage. Also, varieties which may not be good when boiled may prove of value for frying, etc. Certain varieties unfit for food, when heavy yielders and of high starch content, may be used for making alcohol, or for other industrial purposes.

SUMMARY

1. The root of yams is largely composed of water amounting on the average to about three-fourths of the fresh weight.

2. The dry matter is largely made up of starch; the latter making up almost three-fourths of the dry matter, the other one-fourth being in the form of crude fiber, crude protein, sugars, ash, oils and fats, etc.

3. The starch content is quite variable in different varieties. The differrence between varieties run from about 60% in the case of 1101 to almost 84% in the case of 957.

4. The sugars in yams are largely in the form of sucrose. *Tugui* is found to contain a relatively higher per cent of total sugars than either the *nami* or the *ubi*.

5. As a whole, in chemical composition the yam root closely resembles the Irish potato and most of the tropical starch-bearing roots.

6. Previous to period of maturity, there is more water but less starch in the yam root than at maturity. After maturity both water and starch decrease.

7. In yams, the percentage of starch is found to bear a general inversely proportionate relation with the percentage of water.

8. The increase of starch on the approach to maturity bears a direct relationship to the decrease of water, while the decrease of starch beyond maturity seems to be independent of the decrease of water.

9. Chemical composition has a close relation to the quality of yams, so far as texture is concerned. Such qualities as odor, flavor, taste, etc., are found to have no relation. The mealy cooked tubers are those high in starch, while the soggy, softer ones are low in starch.

10. High starch content is not always accompanied by good odor, flavor and taste.

11. In cooking yams, color is not greatly changed but the sticky mucilaginous substance invariably present in the fresh tuber is generally lost through the process.

12. The *tugui* is generally sweeter than either the *ubi* or the *nami*.

13. Excellent food can be prepared from the poisonous *nami* (*D. hirsuta*) through proper manipulation.

14. The best varieties for starch content are: Coll. No. 942, 957, 1098, 943, 952, 959, 329, 960, 330 and 2612.

15. The best yielders are: Coll. No. 88-Big, 331, 1561, 956, 1103 and 1369.

16. The best in cooking quality are: Coll. No. 938, 942, 956, 1098, 943, 952, 959, 329, 962, 330 and 2612. The poorest in cooking quality are: 88-Big, 956, 958 and 1369.

17. Roots of yams should not be dug previous to the period of maturity for there is less starch at this time and generally the quality is poorer.

18. On the other hand, they should not be left too long in the ground after maturity or be kept too long in storage for there is then a decrease of starch.

ACKNOWLEDGMENT

The writer desires to extend his thanks to Assistant Professor F. W. Ashton for his valuable criticisms and suggestions during the progress of this work, and to Mr. F. B. Santos for supplying the materials and other necessary data.

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COLLEGE NOTES

In the last University Commencement, the following students from the College of Agriculture received their degrees: *Bachelor of Science in Agriculture* —Pantaleon Bautista y Tablante; José M. Trinidad. *Bachelor of Agriculture* —Emilio M. Africa; Vicente Aragon y Bumanlag; Basilio Ramos Bautista; Arsenio Bayla y Montoya; Santiago Festin; Pedro Layosa y Makalindog; Valentin Macasaet, Jr.; José Mariano y Garcia; Faustino Otanes y Quesales; Alfonso de la Paz y Juico; Eduardo Quisumbing y Argüelles; Leon M. Romero; Claro Samonte y Carlay; Francisco Santos y Basa; Gregorio C. Santos; Anastasio Teodoro y Lalota. *Master of Science*—Joseph A. Cocannouer; Francisco Quisumbing y Argüelles; Leopoldo B. Uichanco.

The C. A. Alumni Association held its annual banquet and meeting in the Hotel de France on April fourth, with an attendance of about forty members.

The new officers of the C. A. Alumni Association, elected in the last meeting, are the following: *President*, B. M. Gonzalez; *vice-president*, José Zamora; *secretary*, Leopoldo B. Uichanco; *assistant secretary*, José S. Camus; *treasurer*, Eduardo Quisumbing.

Among the recent projects of the C. A. Alumni Association is the erection of an Alumni Hall in the college campus. The funds for the purpose are to be raised mainly by loan from the members at interest of 4%. It is expected that a sufficiently large sum will be collected to enable the laying of the corner stone and the starting of the preliminary work on the building this year. The hall, when completed, will be made self-supporting and will be expected to pay off its indebtedness by renting the rooms to the juniors and seniors of the college.

With a total enrolment of about a hundred students, the following summer courses are now being given at the College of Agriculture: Botany I and Botany III; Mathematics I and Mathematics III; Zoology I and Entomology (for students who have been either conditioned or reported incomplete); and Chemistry I.

The college received on memorandum receipt from the Bureau of Agriculture one Nellore bull and five cows, one Berkshire boar and three sows, and a pen of Rhode Island Red chickens. These animals are placed in the college for instructional purposes.

On the twenty-second of last March, a fire visited the barrio of San Antonio, near the College of Agriculture, destroying about forty houses and rendering homeless many of the college students residing in that place.

The College Co-operative Company, Inc., which operates on a capital of ₱1,200, is transacting an average monthly business of ₱1,000. In the last meeting of the stockholders, a rebate of 20% on purchases was declared, after deducting the sum of ₱381.00 for building fund.

Professor F. W. Foxworthy, who, as announced in a previous issue of this paper, retired from the government service, donated his shares in the College Co-operative Company to that corporation, of which he is one of the founders and first directors.

The following changes of address of College of Agriculture alumni are announced: Antonio Lejano, from Lumban, Laguna, to Bureau of Agriculture, Manila; Eutiquio Zulaybar, from Surigao, Surigao, to Calbayog, Samar; Dionisio Pastorfide, from Manila to Dumaguete, Oriental Negros.

Mr. Mariano B. Raymundo, B. S. A. (Wisconsin), instructor in economics in this college, is planning to sail for the United States on June tenth. He will be accompanied by Mr. Anastasio L. Teodoro, '18, and Mr. Anastasio Lipayon.

Mr. José Q. Dacanay, assistant in economics in this college, has been detailed to the Department of Agriculture and Natural Resources, where he is working in connection with the food campaign.

Mr. Joaquin Ruiz de Arana, for several years chief mechanician of this college, presented his resignation effective April first in order to accept a position with the Hacienda de Calauang.

CORRECTIONS

In the issue of this paper for March, 1918, the following typographical errors were noted, but too late to be corrected in that number:

Page 185, column 2, line 10—change full-pledged to full-fledged.

Page 193, column 1, line 28—change millimeters to meters.

Page 194, column 1, line 27—add district as 3rd word.

Page 201, column 2, line 36—italicize assulta.

Page 210, column 1, line 25—change Day to May.